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EMPIRE^{*}

MICROWAVE IMPULSE GENERATOR

MODEL IG - 118

SINGER
INSTRUMENTATION



INSTRUCTION MANUAL

EMPIRE*

MICROWAVE IMPULSE GENERATOR

MODEL IG - 118



*A Trademark of THE SINGER COMPANY

Precision electrical and electronic instruments for measurement

THE SINGER COMPANY • METRICS DIVISION

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- | | |
|--|--|
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| 2. Serial Number | 6. Approximate number of hours of use |
| 3. Description of trouble ⁽²⁾ | 7. Has maintenance action been previously requested? |
| 4. Test instruments used | 8. Other comments |

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(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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SECTION I

GENERAL DESCRIPTION

1. Purpose of Equipment

Impulse Generator Model IG-118 is designed to serve as a calibrating standard for Noise and Field Intensity Meters for the measurement of noise susceptibility of receivers, bandwidth determination and receiver alignment. It may also be used for noise figure measurements, transient response study, gain check of microwave tuners or as a signal source for broad band amplifiers and the evaluation of spectrum analyzers. This Impulse Generator is capable of producing pulses of extremely short duration (Fractional millimicroseconds), which result in a very broad R. F. spectrum.

2. Equipment Specifications

The Impulse Generator is contained in a metal cabinet 19-1/8" wide x 10-5/8" high x 10-3/8" deep. Single phase AC voltage of 115 volts, 50-60 cps is required for its operation. The sturdy construction of the instrument permits field as well as laboratory use. The frequency spectrum produced by Model IG-118 is from 1000 MC to 10,000 MC. Its output is constant within $\pm 1/2$ DB across the frequency range. The instrument has an output impedance of 50 ohms and a maximum output level (peak) of 9,000 microvolts per megacycle bandwidth, adjustable over a 20 DB range by means of a continuously variable attenuator. The pulse repetition rate is continuously adjustable from 2.5 cycles to 2500 cycles per second in three ranges. The pulse width is 5×10^{-11} seconds. The pulse polarity, indicated on the front panel, automatically reverses every 10 seconds.

3. Principle of Operation

The pulses are obtained by discharging a coaxial line through a pair of contacts into a load impedance. The pulse polarity switching is accomplished by means of a 12AU7 acting as a multivibrator. The repetition rate generator also consists of a 12 AU7 operating as a multivibrator. It's frequency of operation is adjusted by means of S2A, S2B, R14 and R16 (see the schematic diagram shown in Figure 11). The signal drives two 6C4 type tubes acting as cathode follower amplifiers. The outputs of these amplifiers operate a transducer which in turn drives a set of contacts for discharging a charged coaxial line at the desired pulse repetition rate. The duration of the resultant pulse is determined by the length of the coaxial line. The polarity of the line charging voltage is reversed every 10 seconds in order to minimize contact metal migration. Since the amplitude of the pulse generated in the coaxial line is, within the operating limits of the equipment, a direct function of the charging voltage, the relative pulse amplitude in DB may be obtained by reading the calibration chart and the D.C. Meter. This meter is actuated by the line charging voltage which is varied by means of a potentiometer R3.

SECTION II

INSTALLATION

1. Location and Function of Controls

All controls necessary for the operation of the equipment are located on the front panel. The controls, switches, connectors and their functions are covered below and are shown in Figure 1.

- a. Power On-Off: This switch controls the application of power to the entire unit as indicated by an amber colored dial light located directly above the switch.
- b. Charging Voltage: This control is located in the lower center of the panel. It determines the amount of DC charging potential applied to the Impulse Generator. The DC potential is indicated by the meter located in the upper left area.
- c. Contact Adjustment-Fine: This control determines the polarity and amount of DC current which flows through the transducer coil, thus setting the position of the generators contact. It is set for optimum contact performance at the operating repetition rate.
- d. Contact Adjustment-Coarse: This is a screw driver adjustment which is locked in position once it is set. It is used only in the initial adjustment of the generator. However, due to the normal wear of the contacts, it will occasionally have to be reset.
- e. Pulse Repetition Rate: These controls, located in the lower right section of the panel, are used to set the pulse repetition rate of the Impulse Generator.
- f. Output Connector: The R.F. output of the Impulse Generator is available at this connector.

SECTION III

OPERATION AND ADJUSTMENTS

1. Operation

The function of the various controls was covered in the preceding section. During the operation of the Model IG-118, the charging voltage control will be the most used. The charging voltage determines the output energy of the generator, thus there must be some way of correlating this voltage indication with the various units of impulse output. This correlation can be made using the chart on the panel which interprets charging voltage into DB above KTB (average power) and DB above one microvolt per megacycle of bandwidth (peak voltage).

Actual measurements of the noise figure of receivers are made in the following manner:

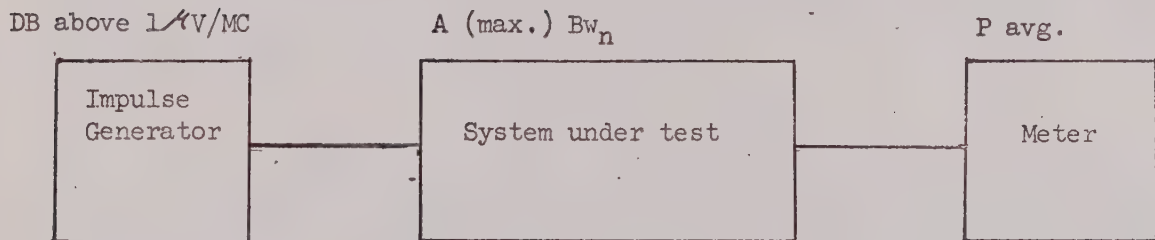
- a. Set up the equipment as illustrated in Figure 2. In addition to the Model IG-118, a power indicating device such as the Hawlett-Packard Power meter, Model 430B and bolometer, Model 476A is required. True response to average power is necessary since only on the basis of average power is the comparison between noise and impulse noise valid.
- b. With the Model IG-118 disconnected, note the noise power of the receiver as indicated on the power indicator.
- c. Connect the Model IG-118 to the receiver input, turn the power on and adjust the repetition rate to the highest possible value.
- d. By means of the charging voltage control, adjust the output level of the Impulse Generator until the output power as read on the indicating device is 3 DB greater than that which existed before (i.e. that due to the receiver alone).
- e. Noting the charging voltage and referring to the chart on the panel, the output of the Impulse Generator in DB above 1 microvolt/megacycle bandwidth is observed.
- f. The pulse repetition rate (fr) of the generator is now measured as accurately as possible.
- g. Insert the output in DB above 1 microvolt/megacycle bandwidth and the repetition rate into the equation below which gives receiver noise figure.

$$F_{db} = (\text{DB above } 1 \mu\text{V/mc}) - 53 + 10 \log_{10} fr$$

This equation will be derived in Appendix I. Graphs have been provided to facilitate this measurement.

NOTES:

1. When measuring noise figure of receivers, the power meter should be inserted before second detector.
2. The meter must respond truly to average power but need not match network impedance.



Test Set-up for Noise Figure Measurements

Figure 2

Figure 3 is a plot of DB above 1 μ V/mc - 53 as a function of charging voltage. Figure 4 is a plot of $10 \log_{10}$ of the repetition rate, f_r , as a function of f . To obtain the noise figure, merely add the quantities obtained from both graphs.

It will be noticed that the minimum value of output that can be accurately set by means of the charging voltage control is 60 DB above 1 microvolt/megacycle of bandwidth. In order to set the output to lower values, insert fixed attenuator pads with low VSWR characteristics, between the generator and load. For example, if 30 DB above 1 microvolt/megacycle is desired, set the generator to 60 DB above 1 microvolt per megacycle and insert a 30 DB pad.

It was pointed out in step "c" of the above procedure that for noise figure measurements, the IG-118 should be operated at the highest possible repetition rate. This precaution is taken in order to avoid non-linearity effects in the receiving system. These effects are particularly troublesome whenever broad band amplifiers are being tested since the impulse peak power accepted by a bandpass system is equal to twice the amplifier passband times the average power input. * That is:

$$P_{\text{peak}} = 2 B_{\text{wn}} \cdot P_{\text{avg}}$$

The above relation applies to all systems, thus it can be seen that an impulse type generator should never be used to test an amplifier without a tuned circuit preceding the first stage. If no selectivity were used, the bandwidth would be very wide and consequently the ratio of peak to average power would be too large for the dynamic capabilities of the receiving system.

2. Adjustments

The adjustment of the Model IG-118 can be divided into two principle steps:

- A. Alignment of the contact within the transmission line of the Impulse Generator, and
 - B. Adjustment of the contacts for optimum contact performance.
- A. Alignment of the Contact within the Transmission Line of the Impulse Generator.

This procedure is undertaken only when the generator is initially assembled or when the contacts are displaced due to shock, etc.

Because of this, the procedure will be discussed in detail in Section IV, Maintenance.

- * This relationship exists for unit impulse, i.e. the ratio of peak to average power is inversely proportional to the repetition rate in cps. This $P_{\text{peak}} = 2 \log B_{\text{w}}/f_r$.

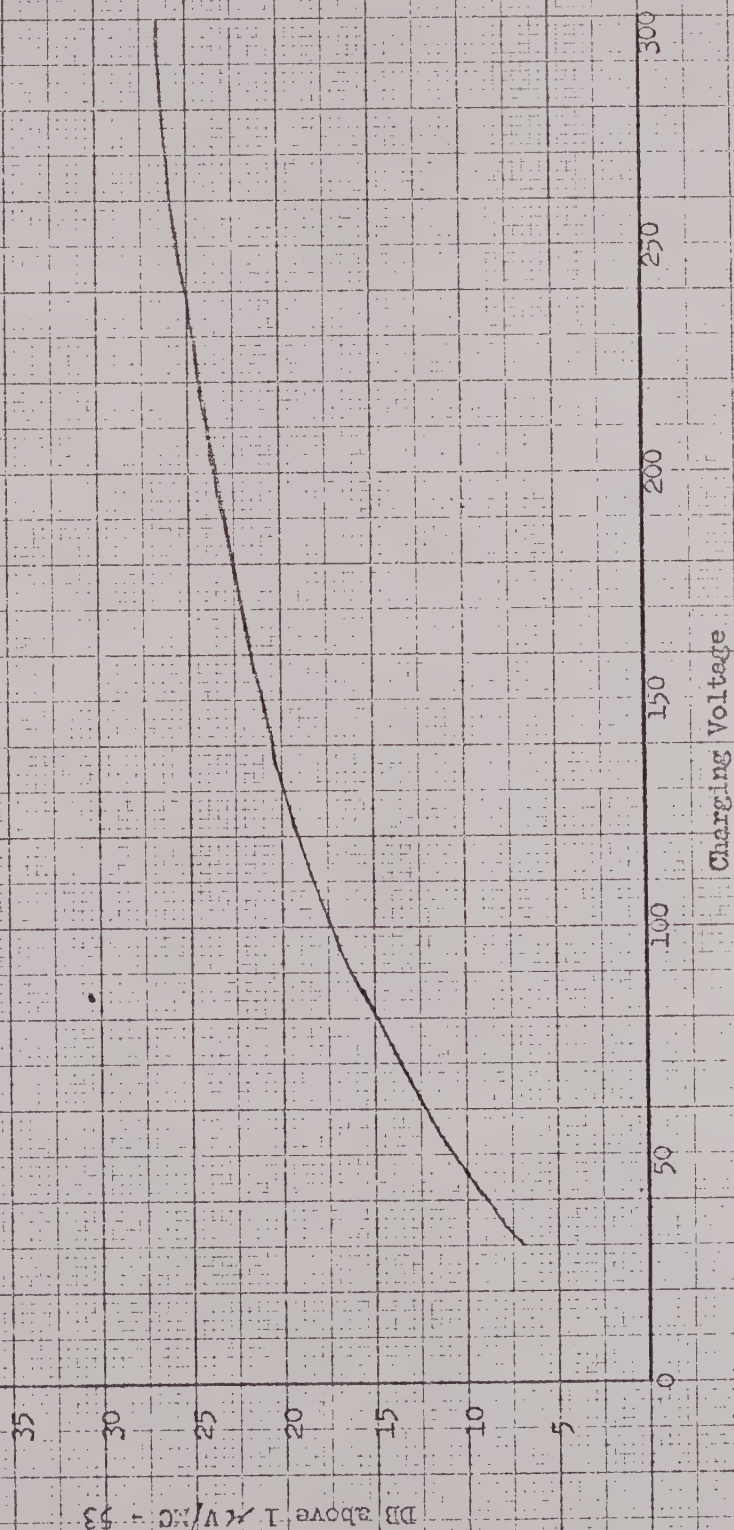


Figure 3
DB above 1 Kv/Mc vs. Charging Voltage

B. Adjustment of Contacts for Optimum Contact Performance

Assuming that the Impulse Generator is perfectly aligned, the next step is the adjustment of the contacts using the mechanical adjustments on the front panel. The charging voltage is set at maximum and the fine contact adjustment is set at midpoint. Having made these preliminary adjustments and using the test set-up shown in Figure 5, set the mechanical contacts in the following manner:

1. Turn the Coarse control fully clockwise with a screwdriver, thus opening the contacts.
2. Adjust the pulse repetition rate to approximately 2000 cps.
3. At this time, the "buzzing" of the generator should be distinctly audible.
4. Watching the oscilloscope screen, begin advancing the Coarse adjustment until an output appears on the screen similar to that illustrated in Figure 6A.

If the contacts have not been advanced enough so that they are actually making contact, but are so close that an output still appears, the oscillogram will be similar to that of Figure 6B. When this condition exists, the contacts will not be heard. The output is a result of arcing and it will be noticed that it occurs almost randomly rather than at a fixed repetition rate. Advancing the contacts too far results in "bouncing" of the contacts. The observed oscillogram will be similar to Figure 6C. The tone produced will seem "muffled" during this condition.

After completion of the above steps, the Coarse contact adjustment should be locked by means of the lock nut. It should now be possible to vary the repetition rate between 2.5 and 2500 cps and obtain a clean output by adjusting the fine control whenever necessary.

Since it is impractical for the contacts to be continuously monitored by means of a scope, the operator should familiarize himself with the aural tone which accompanies clean output and reset the fine control for this tone whenever it is required.

B. Adjustment of Contacts for Optimum Contact Performance

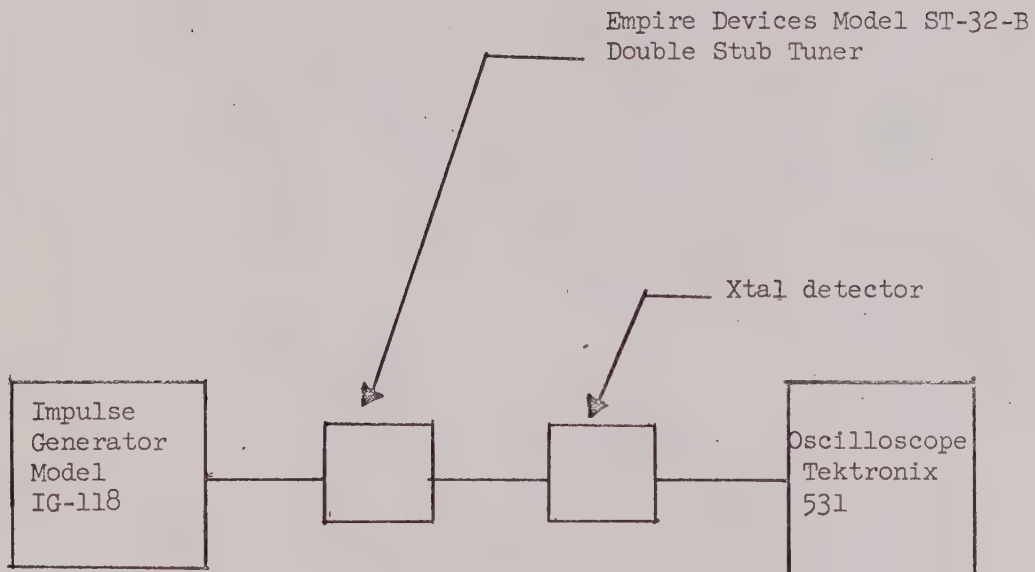
Assuming that the Impulse Generator is perfectly aligned, the next step is the adjustment of the contacts using the mechanical adjustments on the front panel. The charging voltage is set at maximum and the fine contact adjustment is set at midpoint. Having made these preliminary adjustments and using the test set-up shown in Figure 5, set the mechanical contacts in the following manner:

1. Turn the Coarse control fully clockwise with a screwdriver, thus opening the contacts.
2. Adjust the pulse repetition rate to approximately 2000 cps.
3. At this time, the "buzzing" of the generator should be distinctly audible.
4. Watching the oscilloscope screen, begin advancing the Coarse adjustment until an output appears on the screen similar to that illustrated in Figure 6A.

If the contacts have not been advanced enough so that they are actually making contact, but are so close that an output still appears, the oscillogram will be similar to that of Figure 6B. When this condition exists, the contacts will not be heard. The output is a result of arcing and it will be noticed that it occurs almost randomly rather than at a fixed repetition rate. Advancing the contacts too far results in "bouncing" of the contacts. The observed oscillogram will be similar to Figure 6C. The tone produced will seem "muffled" during this condition.

After completion of the above steps, the Coarse contact adjustment should be locked by means of the lock nut. It should now be possible to vary the repetition rate between 2.5 and 2500 cps and obtain a clean output by adjusting the fine control whenever necessary.

Since it is impractical for the contacts to be continuously monitored by means of a scope, the operator should familiarize himself with the aural tone which accompanies clean output and reset the fine control for this tone whenever it is required.



Test set-up for contact adjustment

Figure 5

OSCILLOGRAMS

Fig. 6 A

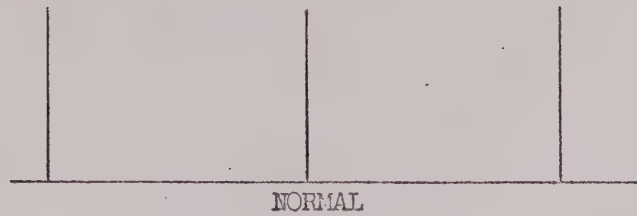


Fig. 6 B



Fig. 6 C

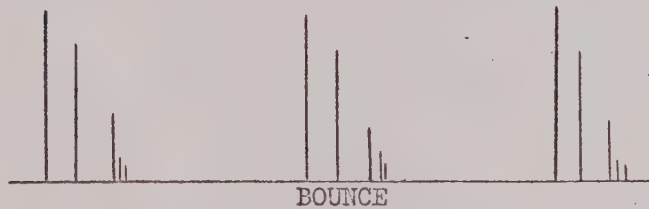


Fig. 6 D

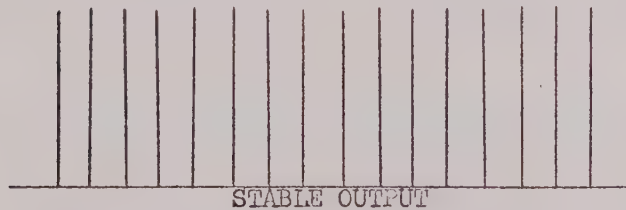
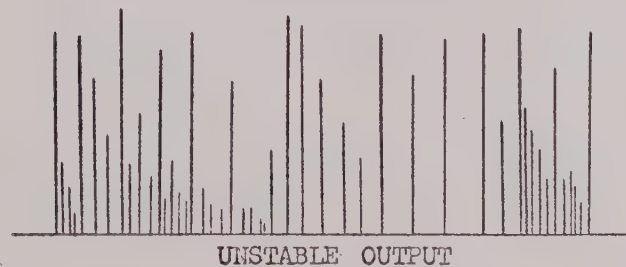


Fig. 6 E



- NOTES:
- A. Normal Contact Behavior
 - B. Arcing at Contacts: Contacts not Touching
 - C. Bouncing Contact: Contacts too Close
 - D. Stable Output: Damped Transducer
 - E. Unstable Output: Undamped Transducer

Figure 6

SECTION IV

MAINTENANCE

1. Test Procedure

The principal tests to be performed on the IG-118 are separated into four groups and will be described accordingly:

A. Frequency Spectrum

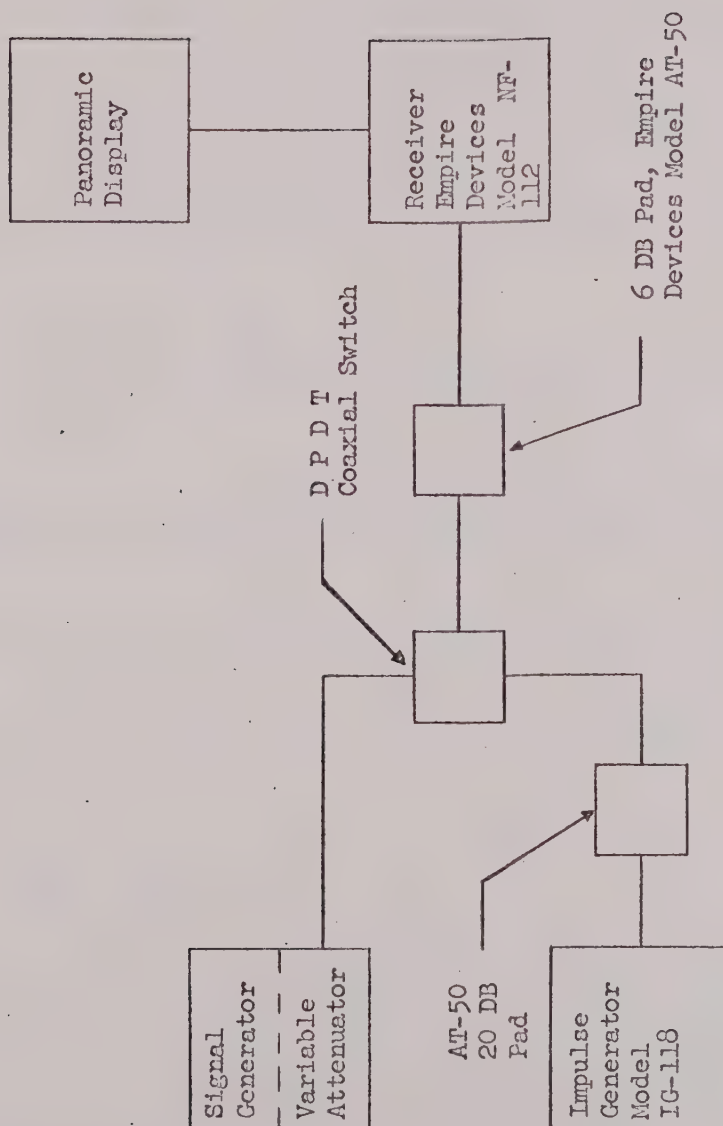
This test consists of viewing the output of a microwave receiver with panoramic display under excitation from the Impulse Generator, then comparing the amplitude level with that of a pulse modulated CW source. The output of the pulse modulated CW source is controlled by a calibrated cut-off type attenuator, which is an integral part of the CW signal generator. In setting up this test, sufficient isolation (20 DB) is put directly on the output line of the Impulse Generator in order to insure a good match. The test set-up is illustrated by a block diagram (Figure 7). In order to insure good matching, a 6 DB pad is placed between the coaxial switch and the input of the receiver. Standard signal generators designed to cover the frequency range from 1000 mc to 10,000 mc are used. The receiver for these tests should have a constant known bandwidth over the frequency range.

1. The output of the Impulse Generator, as shown by the panoramic display, is observed and the peak amplitude level determined.
2. The pulse modulated signal generator is tuned to the frequency of the receiver.
3. The power setting controls of the signal generator are set in order to calibrate the output attenuator.
4. The attenuator is adjusted to give the same amplitude level as that obtained with the Impulse Generator. The dial setting of the calibrated attenuator is taken as an indication of the relative output spectrum of the Impulse Generator.

The above procedure is followed for test frequencies in whatever increments are desired.

B. Contact Behavior

The performance of the Impulse Generator switching action is observed using the set-up illustrated in Figure 5. The repetition rate is varied through its entire range (2.5 to 2500 cps) and in every case it should be possible to obtain stable output and normal contact behavior, by means of the fine contact adjustment.



Frequency Spectrum Test Set-up

Figure 7

C. Stability

It should be possible to observe the stability of the Impulse Generator while performing the tests under Number 1 B (Contact Behavior) of this section. The amplitude of the observed pulses should remain relatively stable and fixed in magnitude. Likewise, the individual pulses should not move excessively in time (time jitter).

If the above tests are performed successfully it can be assumed that the Impulse Generator driver is functioning properly.

2. Alignment of the Contact within the Transmission Line of the Generator

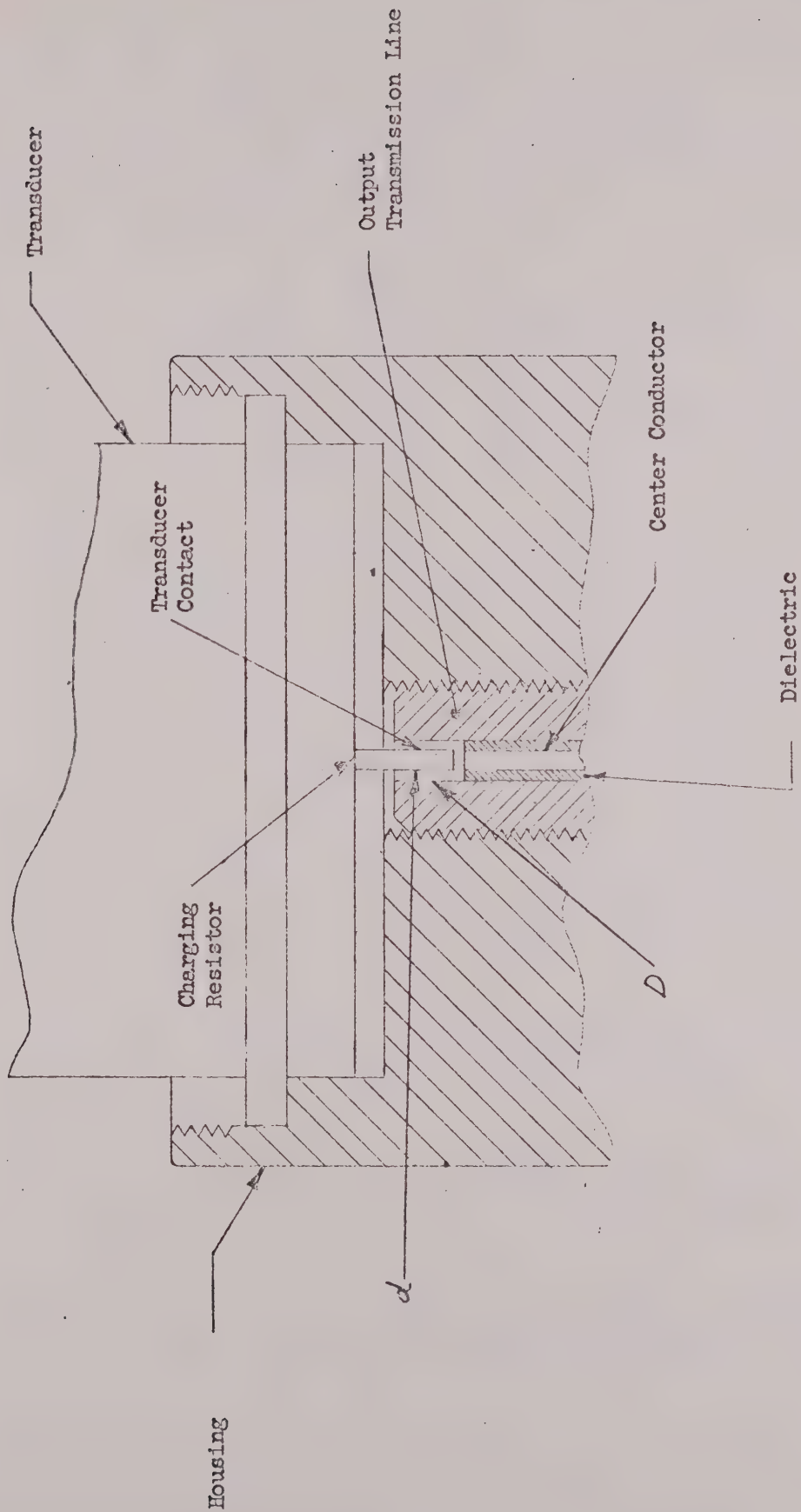
Since the spectral output of an Impulse Generator depends on the impedance characteristics of the discharge output lines, it is imperative that the contact (which is the center conductor of the discharge line) be absolutely centered within the transmission line. No realignment of the contact within the transmission line should be necessary unless the assembly is dismantled. In order to do this, a centering method utilizing the following components is used.

- a. The generator housing.
- b. The transducer (this refers to the entire assembly of contact, diaphragm, charging resistor, electromechanical movement, coil and case).
- c. Two oval point set screws, set 90° apart on the periphery of the housing and passing through the wall of the housing into the inner chamber.
- d. Two spring loaded screws with a tapped hole through their centers, into which are set "dog-point" set screws.
- e. A calibrated adjusting tool which translates the radial movement of the oval set screws into angular degrees. (Empire Devices part #A-7107).

The following procedure may be used for alignment.

NOTE: The discharge resistor must be removed from the side of the output connector.

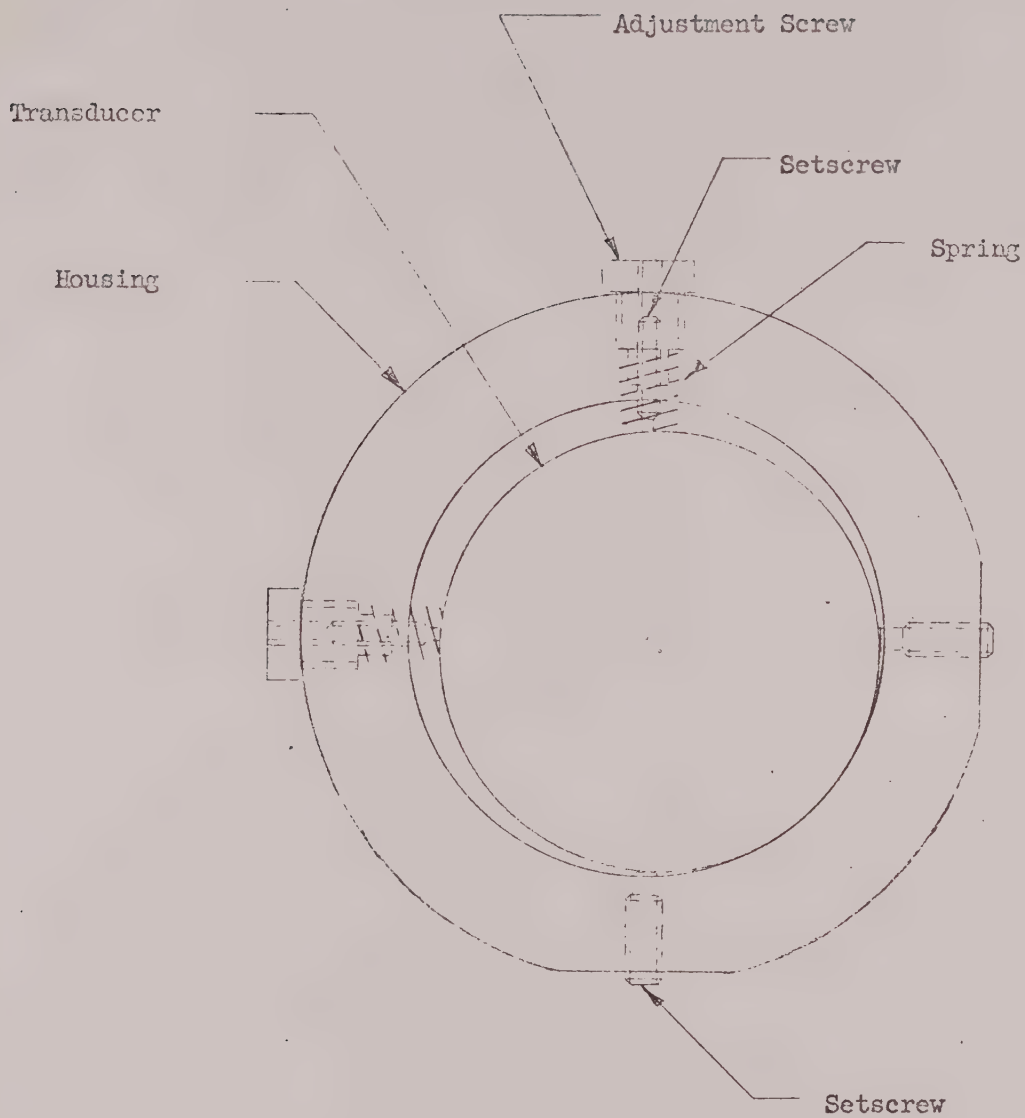
1. The transducer is set into the generator housing so that the contact falls into the transmission line but short of touching the output line's center conductor (see Figure 8). This condition can be checked by connecting a megohmmeter between the charging voltage terminal of the transducer and the center conductor of the output line. If the contact touches the center conductor, the meter will read the charging resistance (100-200 megohms.) The transducer's locking ring is screwed into place finger tight so that it holds the transducer firmly yet not so tight as to prevent side motion during the alignment procedure.



Transducer and Housing
Assembly (A)

Figure 8

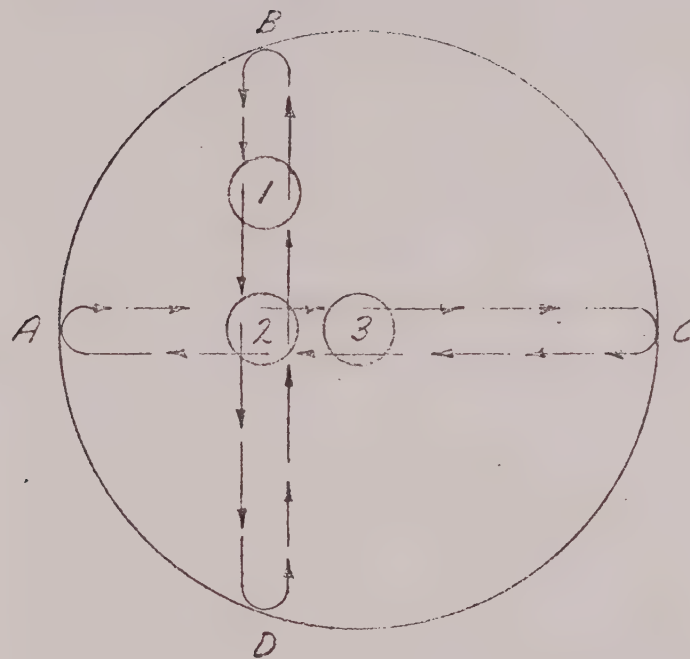
2. The two adjusting set screws are set into the housing and advanced just enough to separate the transducer's bearing surface from the housing at points where the screws are inserted as shown in Figure 9. The purpose of this step is to insure that the insertion of the spring loaded screws will not push the transducer so far to one side as to cause breakage of the contact.
3. Insert the two spring loaded screws.
4. The above step fixed the transducer between four bearing points. It should now be possible to move the transducer in two directions (90°) apart and cause the transducer contact to touch the inner wall of the transmission line at four points. Contact is indicated by connecting the megohmmeter between the housing and the charging voltage terminal of the transducer. The setting screws should be turned in and out with a hexagonal wrench to insure that contact is made at all four points before the adjusting tool is used.
5. The adjusting tool is then used for the actual centering. The way in which centering is accomplished is more clearly demonstrated with the aid of Figure 10. It should be remembered that the adjusting tool translates radial movement of the setting screws (and therefore movement of the transducer in the same direction) into angular degrees as shown on the tool's dial. The procedure is relatively simple. For example, referring to Figure 10, assume that the position of the contact within the transmission line is such that the contact is at 1. Assume also that the set screws are bearing at points A and B while the tension springs return pressure from C and D. By means of the tool, a set screw (either of the two) is then turned. Let us say that B is turned, pushing the contact toward D. This is continued until contact is just made at D, at which time the indicated angle on the tool's dial is noted. The tool is then turned until contact is just made at B and again the angle is noted. The tool is then turned until the pointer indicates an angle half-way of the arc traveled between points D and B.
6. Repeat step 5 for the other set screw. This time, the contact moves from 2 towards C (see Figure 10) at which time the angle is noted, back to A where the angle is again noted, and finally to 3 which should be the exact center of the transmission line if the alignment has been performed carefully.
7. The locking set screws are then inserted into the spring loaded screws until they are tight against the transducer. Over these and the set screws are put another set of screws to doubly insure that they will not loosen.
8. The differential screw-gear is then turned so that the stop pin is opposite the pinion gear (180° apart on the diameter of the differential gear). The megohmmeter is then again connected between the center



NOTE: This illustration is not to scale.

Transducer and Housing
Assembly (B)

Figure 9



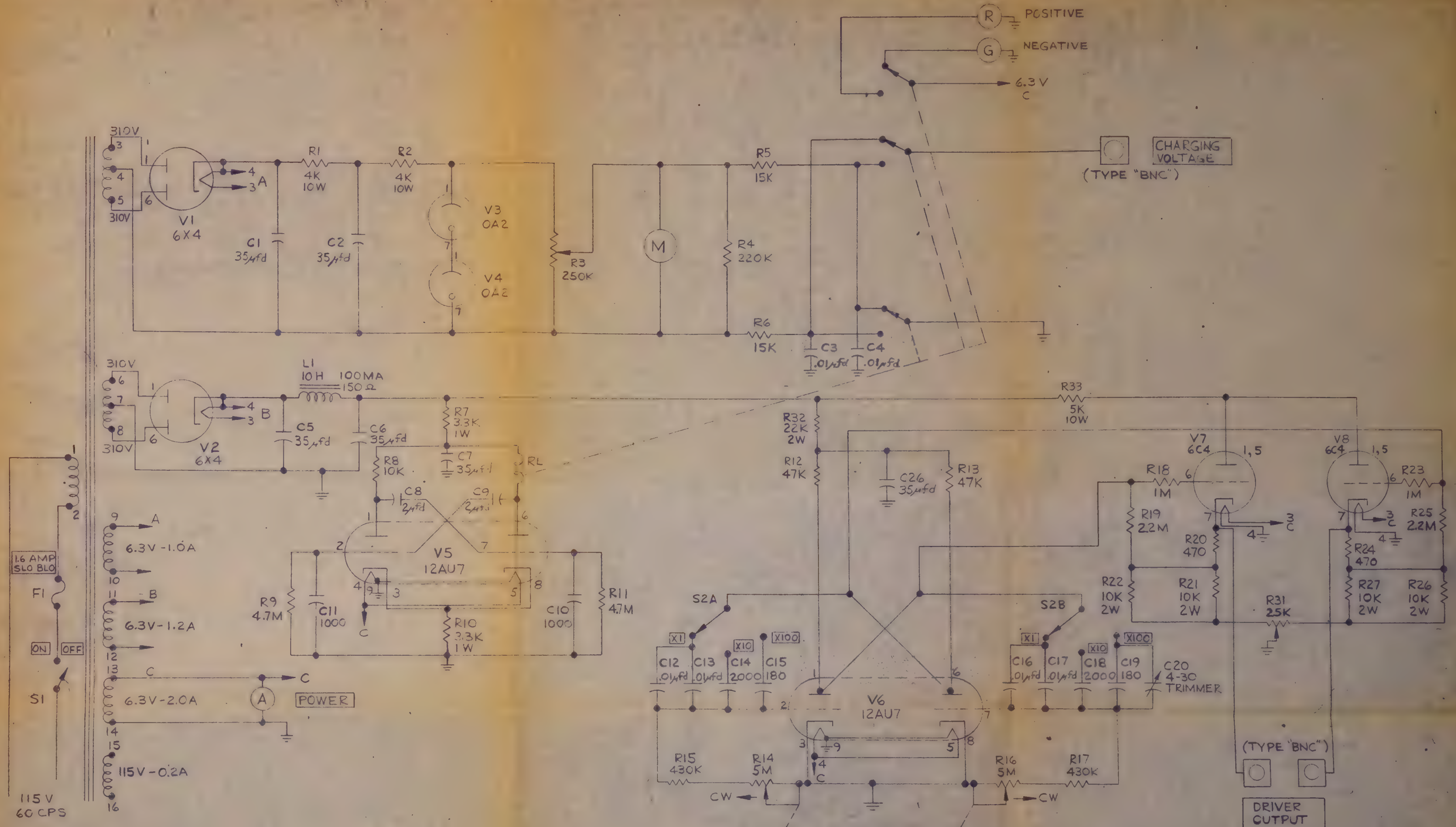
Adjustment Procedure

Figure 10

conductor of the output line and the charging voltage terminal of the transducer. The entire transmission line is then turned into the housing until the center conductor touches the transducer contact (as indicated by the meter which will measure the charging resistance). After contact is made, the transmission line is withdrawn $1/8$ of a turn and the clamping screws (located on the spider) are tightened. This completes the generator alignment.

NOTE: Any time the transducer is to be removed, the two spring loaded hex head screws must first be removed to prevent breaking the resistor.

APPENDIX I
THEORY OF IMPULSE GENERATORS



T-1

DIAL LIGHTS:
A-AMBER
R-RED
G-GREEN

CAPACITORS:
ALL VALUES IN MICRO-MICRO FARADS
UNLESS OTHERWISE SPECIFIED.

RESISTORS:
1/2 WATT UNLESS OTHERWISE SPECIFIED.

METER:
0-300 VOLT VOLTMETER
RUGGEDIZED, SEALED.

ITEM		QTY.	DESCRIPTION	REMARKS
MATERIAL			IMPULSE GENERATOR DRIVER SCHEMATIC	
FINISH			UNLESS OTHERWISE SPECIFIED. 1. DIMENSIONS ARE IN INCHES 2. TOLERANCES FRACTIONAL $\pm 1/64$ DECIMAL $\pm .005$ ANGULAR $\pm .005$ 3. BREAK ALL SHARP CORNERS AND EDGES 4. DO NOT SCALE THIS DRAWING.	QUANTITY
				SCALE
			DRAWN	AEF 2-9-56
			CHK'D	
1 1G-118			APP'D	
REQ. USED ON				
THE SINGER CO. METRICS DIVISION BRIDGEPORT, CONN.				00711- F

REVISIONS	REVISIONS
REDRAWN REV'D IN OBSOLETE	1
CHANGED V2 LX4	2
CHANGED V3 LX4	3
CHANGED V4 LX4	4
CHANGED V5 LX4	5
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CHANGED V77 LX4	77
CHANGED V78 LX4	78
CHANGED V79 LX4	79
CHANGED V80 LX4	80
CHANGED V81 LX4	81
CHANGED V82 LX4	82
CHANGED V83 LX4	83
CHANGED V84 LX4	84
CHANGED V85 LX4	85
CHANGED V86 LX4	86
CHANGED V87 LX4	87
CHANGED V88 LX4	88
CHANGED V89 LX4	89
CHANGED V90 LX4	90
CHANGED V91 LX4	91
CHANGED V92 LX4	92
CHANGED V93 LX4	93
CHANGED V94 LX4	94
CHANGED V95 LX4	95
CHANGED V96 LX4	96
CHANGED V97 LX4	97
CHANGED V98 LX4	98
CHANGED V99 LX4	99
CHANGED V100 LX4	100

APPENDIX I

THEORY OF IMPULSE GENERATORS

The Impulse Generator here described has been designed so that it is capable of producing periodic pulses of such shape and duration that they contain energy components from a repetition rate to 10,000 mc. The pulses are produced by discharging a small length of charged lossless coaxial transmission line into an impedance through a mechanically vibrating contact. By proper choice of transmission line impedances, it is possible to produce periodic transients having a uniform frequency spectrum out to a predetermined frequency by applying a step voltage through a lumped resistance to the coaxial transmission line. For the purpose of analysis the generator may be considered as an initially uncharged uniform transmission line of characteristic impedance Z_0 to which a step function voltage V is applied through a resistance R . If the ratio of the load termination R to the characteristic impedance Z_0 of the transmission line is properly chosen, the spectrum of the pulse train will be essentially flat to a frequency approximately equal to the resonant frequency of the transmission line. The resulting pulse train will decay exponentially as a function of the reflection coefficient.

For an impulse generator whose resonant frequency is about 10 KMC, the individual pulses in the train have a width of about 50 micromicroseconds (5×10^{-11} seconds) and the effective time duration of the wave train is about 350 micromicroseconds. With a reflection coefficient (Γ) of $-.1717$ a reasonably flat spectrum is obtained up to a frequency of $0.9 f_0$ (where f_0 is the resonant frequency of the transmission line).

If a highly selective circuit is excited by a voltage impulse, the voltage output oscillates at the resonant frequency of the selective circuit. The envelope of the R.F. oscillation decays in time as a function of the bandwidth of the tuned circuit and the peak envelope voltage is proportional to the peak impulse input voltage to the tuned circuit.

The magnitude of the voltage spectrum of a generator $A(f)$ in microvolts/megacycle of bandwidth depends, for reasons already mentioned, entirely on the geometry and DC charging potential V_0 of the impulse generator. The spectral intensity in microvolts/megacycle is defined for practical purposes as follows:

It is equal to the number of RMS sine wave microvolts (unmodulated) applied to the input of the measuring device as its center frequency, which will result in a maximum response at the output equal to that resulting from the pulse being measured, divided by the effective impulse bandwidth of the circuit in megacycles.

The spectrum of an impulse, from the purely mathematical standpoint, is considered to extend as far into the negative frequency domain as into

the positive, and a physical bandpass filter or amplifier to which the spectrum is applied responds as if it were receiving not only the energy in its actual passband but also that in the corresponding negative frequency band.

Let $A(f)$ represent the magnitude of the mathematical voltage spectrum in V/cycle/sec. and S the effective spectral intensity in V/cycle/DC charging voltage on the transmission line, the discharge of which generates the impulse. Then:

$$S = 2 \frac{A(f)}{V_c}$$

where V_c is the DC voltage to which the line is charged.

The power output from a filter with a random noise bandwidth $BW(n)$, produced by an impulse generator at its input is given by the following relation:

$$P_o = f_r \cdot \frac{V_c^2 S^2}{R} \cdot a^2 \max. BW(n) \quad (1)$$

P_o = Output power in watts of the filter assuming output R =input R .

$BW(n)$ = Random noise bandwidth of the filter in cycles/sec.

$a \max.$ = Maximum voltage gain of the filter in its bandpass.

R = Input impedance of filter.

S = Impulse strength into filter in RMS volts/cycle/volt of DC Charging voltage.

f_r = repetition rate in cycles/sec.

V_c = charging voltage in volts

The relation between the impulse strength and the voltage spectrum amplitude is given by definition:

$$S = 2 \frac{A(f)}{V_c} \quad (2)$$

The impulse generator's calibration chart gives Y DB above one microvolt/megacycle with reference to V_c , as supplied to a 50 ohm load. Thus in terms of the impulse generator calibration the following holds:

$$\mu V \text{ RMS/MC} = V_c S = \log_{10}^{-1} \left(\frac{Y}{20} \right) \quad (3)$$

where Y = DB above 1 $\mu V/MC$

substitution of 3 into 1 gives:

$$P_o = f_r \frac{10^{-24}}{R} \left[\log_{10}^{-1} \left(\frac{Y}{20} \right) \right]^2 \cdot a^2 \max. BW(n) \quad (4)$$

The use of the impulse generator for noise figure measurements is based on this formula.

Definition of noise figure from the deterioration ratio:

$$F = \frac{P_{g*}/KT \cdot BW(n)}{P_o / N_o} = \frac{N_o}{G \cdot KT \cdot BW(n)} \quad (5)$$

$$P_g^*/P_o^* = \frac{\text{available signal power in}}{\text{available signal power out}} = \frac{1}{\text{available gain}}$$

Available power is that which would be delivered to a match load:

N_o^* = available noise power output

Total noise power generated in a resistor:

$$P = 4 KT BW(n)$$

Available noise power from a resistor working into a hypothetical noiseless resistor:

$$P_r^* = KT BW(n)$$

K = Boltzmann constant = 1.374×10^{-23} joule/ $^{\circ}K$

T = absolute temperature. Room temperature as reference
chosen with $T_o = 291^{\circ} K$

Hence $KT_o = 4 \times 10^{-21}$ (watts/cycle/sec.) If equation 5 is developed further we find:

$$F = \frac{E^2}{a^2 4 R_g KT BW(n)} \quad (\text{noise output})$$

and if we proceed in such a way that we note the sine wave generator EMF necessary to double the noise output power measured when the signal generator is not energized, then the noise figure of the tested amplifier is given by:

$$F = \frac{E_g^2 (\text{for doubling})}{4 R_g} \cdot \frac{1}{KT BW(n)}$$

for amplifier input impedances (real part) matched with the generator impedance:

$$R_g = R_l$$

F becomes simply the ratio of the available generator power necessary for doubling the noise output of the amplifier, to the available noise power at the input resulting from the resistor R_g . If a sine wave generator is used, the random noise bandwidth BW_n has to be known exactly. This disadvantage is avoided by using an impulse generator which delivers a spectrum covering the whole frequency region of the amplifier. Converting F to decibels $10 \log_{10} F = \text{XDB Noise power}$

YDB = I.G. DB output setting, $R_g = 50$

$$\text{XDB} = \text{YDB} + 10 \left[10 \log_{10} f_r - 24 - \log (50 \times 4 \times 10^{-21}) \right]$$

$$\text{XDB} = \text{YDB} - 53 + 10 \log_{10} f_r$$

Noise Figure in DB equals generator impulse setting (minus attenuation pad) in DB above one microvolt RMS/megacycle necessary to double the noise power output, minus 53 plus repetition rate in DB above one cycle/second.

The basic circuit of the Impulse Generator driver consists of a free running multivibrator and push-pull cathode follower power drivers.

The multivibrator (V6) will determine the repetition rate of the Impulse Generator driver. The cathode followers (V7 and V8) operating in push-pull act as power amplifiers delivering the driving power to the Impulse Generator.

A free running multivibrator (V5) with a relay coil in the plate circuit of one of the tube halves, controls the polarity of the charging potential. This polarity is changed every time that half of the tube conducts, the rate of change being controlled by the time constants of the grid circuits. The switching time is approximately 10 seconds and should be set so that it is equal on both halves of the switching cycle. This is important if the main advantage of charging polarity is to be realized, viz: prevention of metal migration at the contacts of the Impulse Generator.

There are two power supplies. One supplies B+ to all the tubes, while the other which is regulated supplies the Impulse Generator with charging potential. The regulated supply is isolated from ground in order to permit grounding on either side. This provides a positive or negative potential to the contacts.

The operation of the transducer is relatively simple. It functions very similar to some types of telephone receivers and transmitters. It consists basically of a metallic (iron) flap placed between the poles of permanent magnets. Around the flap is wound a coil which is excited by a voltage (sinusoidal, square or pulse) causing the ends of the flap to assume magnetic poles depending on the direction of current flow through the coil. Thus the flap is caused to vibrate back and forth between the magnets. The contacts of the generator are connected to this flap by means of a bakelite rod and supporting diaphragm.

